REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*

2. REPORT TYPE
Technical Papers

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER
2302

5e. TASK NUMBER
MIG2

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

8. PERFORMING ORGANIZATION REPORT

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
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10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:

a. REPORT	b. ABSTRACT	c. THIS PAGE
Unclassified	Unclassified	Unclassified

17. LIMITATION OF ABSTRACT
A

18. NUMBER OF PAGES

19a. NAME OF RESPONSIBLE PERSON
Leilani Richardson

19b. TELEPHONE NUMBER *(include area code)*
(661) 275-5015

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

36 separate items are enclosed

4/1/1

✓ DTJ

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MEMORANDUM FOR PRS (In-House /Contractor Publication)

FROM: PROI (TI) (STINFO) 21 October 1999

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-TP-1999-0196**
Smith, C.W.; Gloss, K.T., Liu, C.T, "Test Geometries for Bondline Cracked Photoelastic Models; Preliminary Results" (VuGraphs)

ASME 1999 Mechanical Engineering Congress and Exposition **(Statement A)**

Item (???)

TEST GEOMETRIES FOR BONDLINE CRACKED PHOTOELASTIC MODELS: PRELIMINARY RESULTS

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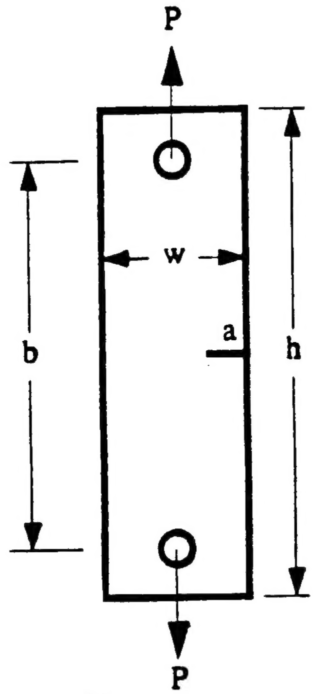
w = 38.1 mm
t = 12.7 mm
h = 127 mm
b = 102 mm
P = 2.74 kgs



		(MPa $\sqrt{m}$)		
a (mm)	a/w	K_{exp}	K_{th}^{*}	% difference
7.54	0.20	12.76	11.84	7.80

* Srawley and Brown, 1967

Fig. 1 Single Edge Crack Results for Artificial Cracks

(**Mode I Algorithm**)

Beginning with the Griffith-Irwin Equations, we may write, for Mode I, for the homogeneous case,

$$\sigma_{ij} = \frac{K_1}{(2\pi r)^{\frac{1}{2}}} f_{ij}(\theta) + \sigma^{\circ}_{ij} \qquad (i.j. = n, z) \qquad (1)$$

where:

σ_{ij} are components of stress,

K_1 is SIF,

r, θ are measured from crack tip(Fig. A-1),

σ°_{ij} are nonsingular stress components.

Then, along $\theta = \pi/2$ the direction of greatest local fringe spreading, after truncating σ_{ij}

$$(\tau_{nz})_{\max} = \frac{K_1}{(8\pi r)^{\frac{1}{2}}} + \tau^{\circ} = \frac{K_{AP}}{(8\pi r)^{\frac{1}{2}}} \qquad (2)$$

where $\tau^{\circ} = f(\sigma^{\circ}_{ij})$ and is constant over the data range, K_{AP} = apparent SIF, $(\tau_{nz})_{\max}$ = maximum shear stress in nz plane

$$\therefore \frac{K_{AP}}{\bar{\sigma}(\pi a)^{\frac{1}{2}}} = \frac{K_1}{\bar{\sigma}(\pi a)^{\frac{1}{2}}} + \frac{\sqrt{8}\tau^{\circ}}{\bar{\sigma}} \left(\frac{r}{a}\right)^{\frac{1}{2}} \qquad (3)$$

where (Fig. A-1) a = crack length, and $\bar{\sigma}$ = remote normal stress

$$i.e. \frac{K_{AP}}{\bar{\sigma}(\pi a)^{\frac{1}{2}}} \text{ vs. } \sqrt{\frac{r}{a}} \text{ is linear.}$$

Since from the Stress-Optic Law:

$$(\tau_{nz})_{\max} = \frac{nf}{2t} \text{ where}$$

n = stress fringe order

f = material fringe value

t = specimen thickness

and from Eq. 2

$$K_{AP} = \tau^{max}_{nz}(8\pi r)^{\frac{1}{2}} = \frac{nf}{2t}(8\pi r)^{\frac{1}{2}},$$

then K_{AP} (through a measure of n) and r becomes the measured quantity from the stress fringe pattern at different points in the pattern.

A typical plot of normalized K_{AP} vs. $\sqrt{r/a}$ for a cracked, bonded specimen is shown in Fig. A-2.

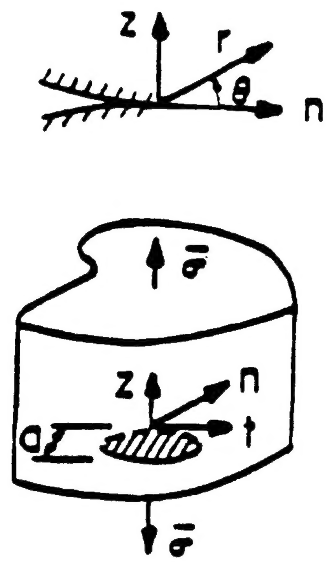


Fig. A-1 Mode I Notation

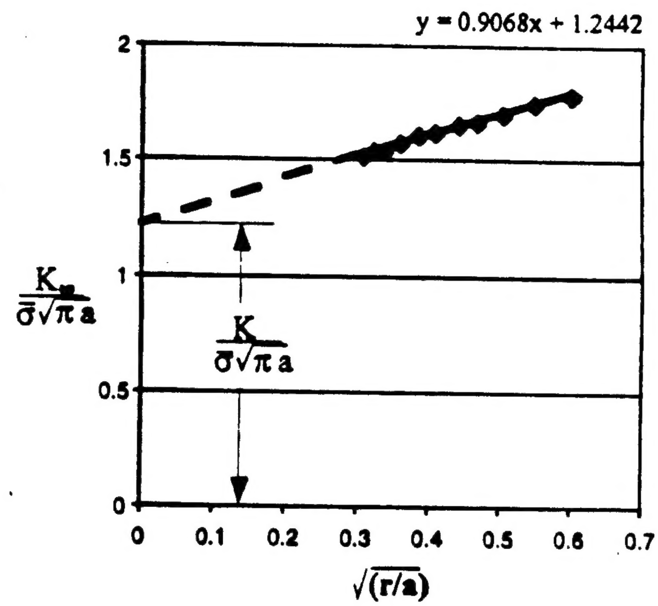


Fig. A-2: Determination of K_I from Test Data for DS4.

Mixed mode algorithm

The mixed mode algorithm was developed (see Fig. 12(a) and (b)) by requiring that

$$\lim_{\substack{r_m \to 0 \\ \Theta_m \to \Theta^\circ_m}} \left\{ (8\pi r_m)^{1/2} \frac{\delta(\tau)^{max}_{nz}}{\delta\Theta}(K_1, K_2, r_m, \Theta_m, \tau_{ij}) \right\} = 0 \qquad (4)$$

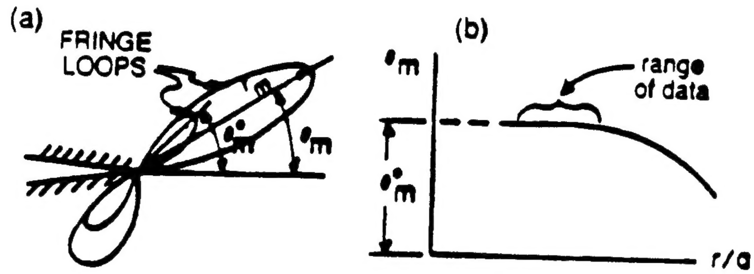


Fig. 12. (a) and (b). Determination of θ°_m.

which leads to

$$\left(\frac{K_2}{K_1}\right)^2 - \frac{4}{3}\left(\frac{K_2}{K_1}\right)\cot 2\Theta^\circ_m - \frac{1}{3} = 0 - - - . \qquad (5)$$

By measuring Θ°_m which is approximately in the direction of the applied load, K_2/K_1 can be determined.

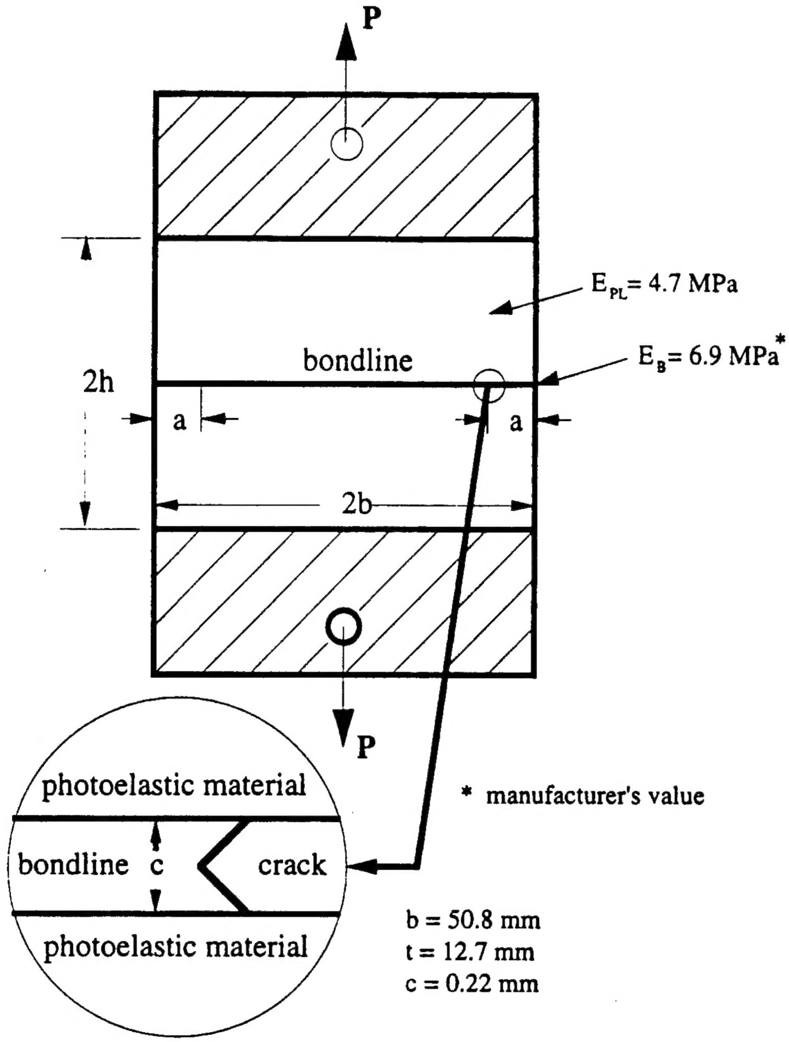
Then writing the stress optic law as

$$\tau^{max}_{nz} = \frac{fn}{2t} = \frac{K^*_{AP}}{(8\pi r)^{\frac{1}{2}}},$$

one may plot $K^*_{AP}/\bar{\sigma}(\pi a)^{1/2}$ vs $\sqrt{r/a}$ as before; locate a linear zone and extrapolate to $r = 0$ to obtain K^*. Knowing, K^*, K_2/K_1 and $\Theta^\circ{}_m$ values of K_1 and K_2 may be determined since

$$K^* = \left[\left(K_1 \sin\Theta^\circ_m + 2K_2\cos\Theta^\circ_m\right)^2 + \left(K_2\sin\Theta^\circ_m\right)^2\right]^{\frac{1}{2}} - - -. \qquad (6)$$

Knowing K^* and Θ°_m, K_1 and K_2 can be determined from Eqs. (5) and (6). Details are found in Ref. [3].



test	a (mm)	h (mm)	a/b	P (kg)
DS2	7.94	50.8	0.16	7.64
DS3	12.7	50.8	0.25	7.64
DS4	17.4	50.8	0.34	7.64
DS5	20.6	50.8	0.41	7.64
DS6	25.4	50.8	0.50	7.64
DS7	27.9	50.8	0.55	7.64
DS8	7.94	25.4	0.16	7.64
DS9	12.7	25.4	0.25	7.64
DS10	17.4	25.4	0.34	5.37
DS11	20.6	25.4	0.41	5.17
DS12	25.4	25.4	0.50	5.17
DS13	27.9	25.4	0.55	5.20

Fig. 2 Bonded Specimens with Double Edge Bondline Cracks

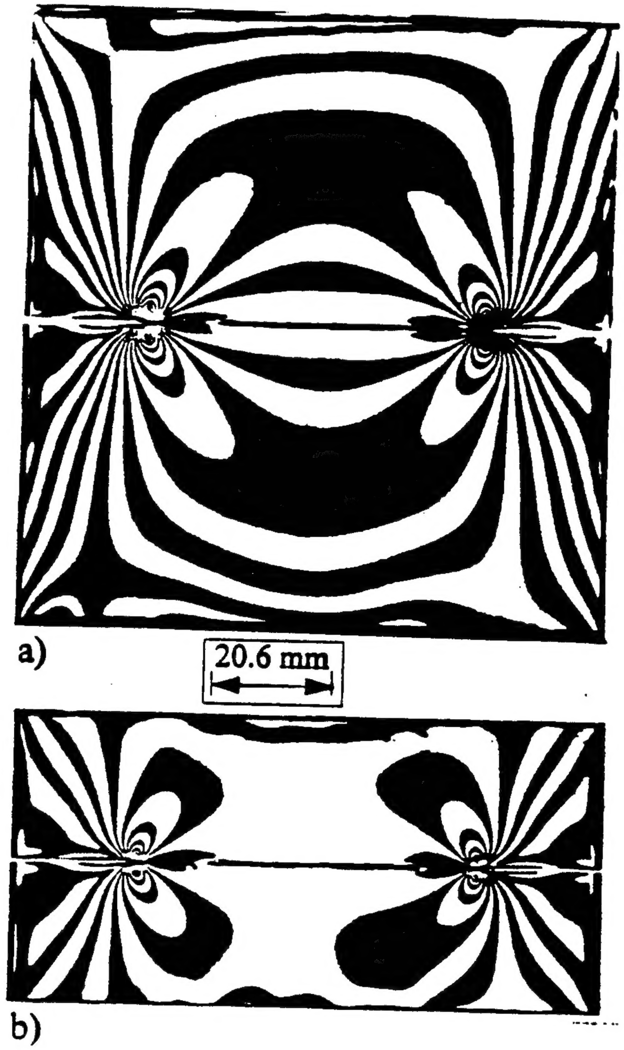


Fig. 3⁺: Global Stress Fringe Patterns for a) Square Specimen, b) Short Specimen.

⁺All fringe patterns have a bright background, (i.e. integral fringes are white, half fringes are black).

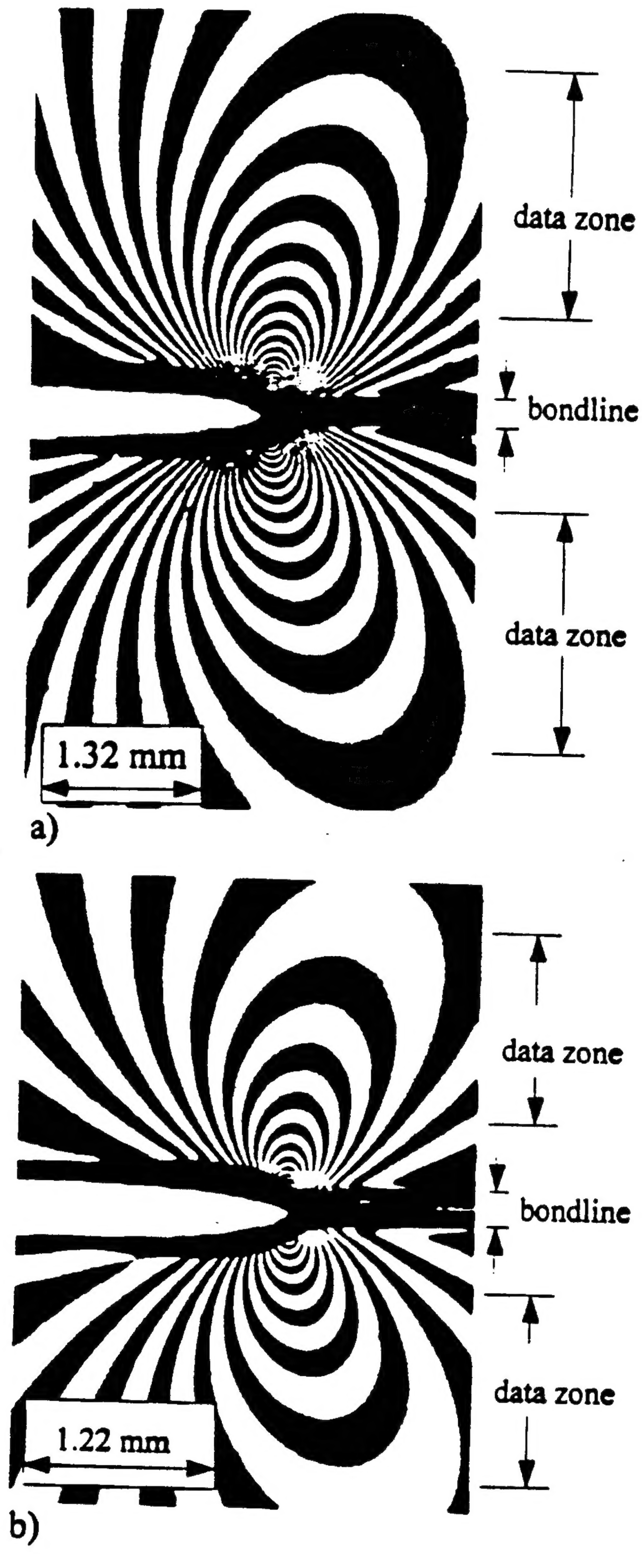


Fig. 4*: Local Stress Fringe Patterns for a) Square Specimen, b) Short Specimen.